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Effect of Supplementation of Rice Straw with Biogas Residual Slurry Manure on the Yield, Protein and Mineral Contents of *Volvariella volvacea* Mushroom

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Volvariella volvacea commonly known as paddy straw mushroom grows well in humid and tropical environment. This is regarded as a delicious mushroom for its flavour and taste. However, the biological efficiency of this is very low in comparison to oyster mushroom. Low productivity is a big hurdle for its commercial exploitation. Although the mushroom is called paddy straw mushroom, it has great affinity towards biomanure . Supplementation of rice straw - the traditional substrate for this mushroom cultivation, with biogas residual slurry manure not only increases its production to a great extent by producing fruit bodies bigger in size and higher in number but also increases the protein content significantly. In addition essential mineral nutrients viz., P, Ca, K, Fe, Cu, Zn and Mn are also increased. So, supplementation of this biomanure for cultivation of tropical mushroom *Volvariella volvacea* may be a step towards its successful commercial exploitation.

Introduction

Spent slurry left in biogas plant after biogas generation is found to be rich in mineral nutrients[1]. So, this biomanure has been used in agriculture on different crops for increasing yield[2].This biomanure has been used successfully for cultivation of *Pleurotus and Volvariella* mushroom[3-5]. Block[6] used municipal garbage for composting and used it for production of button mushroom. The major difference in these two processes of composting is that one is anaerobic while the other is aerobic. It is reported[7] that prevailing high anaerobiosis in the biogas digester reduces common plant pathogen to a great extent in the residual organic mass which help the mushroom to grow in lesser competetion and produce more hygenic mushroom fruit bodies. Moreover, the anaerobes degrade the lignocellulosic constituents considerably making them easily assimilable to the mushroom. *Volvariella spp.* show great affinity towards compost although it can grow well on paddy straw only. So, the study was undertaken to evaluate and compare the yield potential and nutritional value of the mushroom grown on rice straw and a combinationation of straw and the said biomanure.

Materials and Methods

Biogas spent slurry manures using raw materials cattle dung, poultry litter and municipal solid waste (MSW) as substrates were collected from Lok Sikha Parishad, Narendrapur Ramkrishna Mission, Child In Need Institute Agricultural Farm, Samali and from biogas pilot plant of Burn Standard Co. Ltd., Howrah respectively. Biogas spent slurry using jute caddis as raw material was obtained from the biogas plant of the Institute.

Chemical composition of the fibre materials and biomanures were determined from air dry samples and expressed on oven dry weight (at 105° C) basis following methods described in Tappi Standard[8]. Similarly total nitrogen and phosphorus were determined following methods described in Jackson[9] and other elements viz., Na, K, Ca, Fe, Zn, Cu and Mn were determined in a Parkin - Elmer model 370 Atomic Absorption Spectrophotometer from ash samples obtained by heating in a Muffle furnace for 6 hours at 550° C using standard methods[10].

Air dry straw and biomanures were used for mushroom bed preparation after proper disinfection. The

Table 1 – Nutrients in the biogas residual slurry bio-manure

Bio-manure sample	Ash Per cent	Elements Present (oven dry basis)								C:N ratio
		per cent				ppm				
		P	N	Na	K	C a	Cu	Zn	Mn	
Cowdung	51.86	0.21	1.33	0.14	.30	0.88	34.8	98.5	397	15.38
Poultry litter	56.77	1.4	1.17	0.15	0.61	3.54	71.3	876.2	1142 .1	17.63
Jute caddis	38.65	0.63	2.02	-	0.33	0.27	46.1	471.4	398	39.79
MSW*	44.21	1.07	3.28	0.25	0.46	7.06	101 6	616.0	1098.1	21.63

*MSW = Municipal Solid Waste, - Not determined

Table 2 – Effect of biogas residual slurry manure *supplementation on yield of *Volvariella volvacea*

Treatments**		Yield of mushroom (g / kg straw)	Biological efficiency (Per cent)	Increase over control (Per cent)
Straw 100 per cent	T0	92	9.2	-
Straw + 0.1 per cent $(NH_4)_2$ HPO_4	T_1	118	11.8	28.2
Straw +Biomanure (1 : 1)	T2	150	15.0	63.0
Straw +Biomanure (2 : 1)	T3	106	10.6	15.2
Straw +Biomanure (1: 2)	T4	98	9.8	6.5

* Jute Caddis was used as substrates in the biogas plant
** The experiment was of 30 days duration

CD at 5 per cent=70.01 and CD at 1 per cent=98.16
Treatment T2 significant at 1 per cent and T1 significant at 5 per cent level, other treatments NS

moisture content in airdry straw was 3.9 per cent and in biomanures from cattledung, poultry litter, MSW and jute caddis were 2.8, 5.04, 12.2 and 2.7 per cent respectively. Mushroom *Volvariella volvacea* was grown in galvanised iron trays (1m X 1m) at 30 -37° C using either rice straw alone or rice straw in combination with 0.1 per cent $(NH_4)_2HPO_4$, bengal gram (*Cicer arietinum*) powder and residual slurry manures obtained from biogas plant in alternate layers following standard methods[11]. Four replications were kept for experiments presented in Table 2 and three replications were kept for experiments presented in Table 3 and 4. Average values of mushroom yield and biological efficiency of mushroom yield has been expressed in gram per kg of straw. Fruit bodies were harvested at just maturity i.e., before opening the volva and fresh weight and respective moisture per centage of mushroom were determined. Two harvests was taken for 30 d experiment and maximum four harvests could be achieved for experiment of 60 d duration. First , second, third and fourth harvests were obtained within 13-15, 22-26, 35-40 and 50-55 d after spawn run. The fruit bodies were dried at 50° C in a hot air oven. Analyses were done using air dry and powdered samples for protein[12] , carbohydrate[13], lipid[14] and mineral nutrients viz., N, P, K, Na, Ca, Fe, Mn, Cu and Zn using methods as mentioned earlier. All results presented are average of replicated sets and are expressed on oven dry weight basis.

Results and Discussions

Results of the experiments are presented in Tables 1-6. Table 1 depicts the mineral nutrient values in biogas residual slurry manures. The manures contain as high as 56.77 per cent ash and are rich in mineral nutrients like N, P, K, Na, Ca, Cu, Mn, and Zn. Jain[2] reported that these biomanures are more effective than farmyard manure. Moreover, prolonged anaerobiosis in the biogas digester causes elimination of the pathogenic microor-

Table 3 – Effect of biogas residual slurry manure as supplementation on yield of *Volvariella volvacea**

Treatments**		Yield of mushroom (g/kg straw)	Biological efficiency (per cent)	Increase over Control (per cent)
Only Straw	T0	135	13.5	—
Straw + Besan (Bengal gram dal powder)	T1	141	14.1	4.4
Straw + Cowdung Biomanure	T2	240	24	77.8
Straw + Poultry Litter Biomanure	T3	153	15.3	13.3
Straw + Jute Caddis Biomanure	T4	180	18	33.3
Straw + MSW Biomanure	T5	149	14.9	10.4

*The experiment was of 30 d duration **Straw:Biomanure was 1:1
CD at 5 per cent=123.77, CD at 1 per cent=176.03
Treatments T2 and T4 significant at 1 per cent and 5 per cent level respectively, other treatments NS.

Table 4 – Effect of biogas residual slurry manure supplementation on yield of *Volvariella volvacea**

Treatments **		Yield of mushroom (g/kg straw)	Biological efficiency (Per cent)	Increase over control (Per cent)
Only Straw	T0	123	12.3	-
Straw + Cowdung Biomanure	T1	482	48.2	390.8
Straw + Poultry Litter Biomanure	T2	157	15.7	27.0
Straw + Jute Caddis Biomanure	T3	143	14.3	15.9

*The experiment was of 60 d duration. ** Straw : Biomanure was 1:1
CD at 5 per cent=591.33 and CD at 1 per cent=896.72.
Treatment T1 significant at 1 per cent level, other treatments NS.

ganisms almost completely and at the same time partial degradation of the lignocellulosic materials take place[7]. So, these biomanures can serve as a good starter and stimulant for improvement of mushroom quality and its yield.

In laboratory culture vigour in growth of *Volvariella volvacea* on potato malt extract broth was found better than in potato dextrose and malt extract broths. Earlier report[15], however, showed that oat agar medium produced maximum mycelial growth for this mushroom. This finding will be helpful for production of spawn of *Volvariella* mushroom on commercial basis.

From results presented in Table 2 it is evident that treatment biomanure from jute caddis in 1:1 ratio with rice straw was significant at 1 per cent level in comparison to control i.e., rice straw alone. Rice straw supplemented with 0.1 per cent $(NH_4)_2HPO_4$ in terms of mushroom productivity was significant at 5 per cent level over control. Supplementation of rice straw with biomanure in the ratio of 2:1 or 1:2 ratio was less effective in terms of mushroom productivity and were not significant in comparison to control. This result corroborates the previous observations[3-5]. Pal[15] found that nitrogen is very essential for cultivation of *Volvariella volvacea* but also noticed that addition of 0.1 per cent urea created problem of mold contamination. Purkayastha *et al.*[16] reported uncontrollable problem of *Coprinus* contamination during cultivation of *Volvariella* mushroom in tropical conditions. In the present method occurrence of *Coprinus* contamination was greatly controlled.

Table 5 – Effect on major constituents in *Volvariella volvacea* due to supplementation by biomanure *

Treatments	Per cent				
	Protein	Carbohydrate	Lipid	Ash	Fibre
Straw 100 per cent	37.2	26.9	9.8	11	14.9
Straw +0.1 per cent $(NH_4)2HPO_4$	43.5	21.5	12.2	8.6	14.1
Straw + Biomanure (1 : 1)	48.9	19	9.3	11.5	11.3
Straw + Biomanure (2 : 1)	41	19.4	9.6	11.4	18.6
Straw + Biomanure (1 : 2)	48.6	21.4	10.4	10.6	9

*See text

Biomanure obtained by use of different substrates viz., cattle dung, poultry litter, jute caddis and municipal solid waste after anaerobic digestion in biogas plants were air dried, pulverised and used along with rice straw for mushroom cultivation. Moisture contents of straw, straw + cowdung, straw + poultry manure, straw + jute caddis, and straw + MSW were 8.12, 9.31, 6.47, 9.0 and 6.16 per cent respectively. Results presented in Table 3 indicate that supplementation of Bengal gram powder at the rate of 2 per cent increased yield marginally over control while cattle dung biomanure increased yield by 77.8 per cent over control. This increase in yield was significant at 1 per cent level. Jute caddis biomanure was less effective and contributed 33.3 per cent increase over control which was significant at 5 per cent level. Among other treatments poultry litter biomanure and MSW biomanure contributed marginal increase of 13.3 and 10.4 per cent over control respectively and eventually these increases were not significant. From analysis of the results it became very clear that cattle dung biomanure supplemented some factor other than nitrogen source to the mushroom because inorganic nitrogen source $(NH_4)_2HPO_4$ and complex nitrogen source like Bengal gram powder could not increase yield significantly. The results are indeed encouraging and need further investigation. Although MSW biomanure was rich in nitrogen content, presence of toxic heavy metals might have restricted the productivity of this mushroom by not allowing the mycelium to propagate and ultimately restricted the mushroom to produce fruit bodies. However, this hypothesis should be verified experimentally for better utilization of MSW biomanure. Nonetheless, the results clearly indicate that biological efficiency of *Volvariella volvacea* can be increased to a great extent with the help of cattle dung biomanure.

In another experiment of 60 d duration presented in Table 4, the maximum biological efficiency achieved was 48.2 per cent by supplementation of rice straw with cattle dung biomanure. This increase in yield was highly significant i.e., at 1 per cent level over control. Increase in productivity by using jute caddis and poultry litter biomanures was marginal and eventually not significant. It was also noted that only cattle dung biomanure was able to produce 4th flash with higher yield potential. Thus it was again evident that when rice straw is supplemented with cattle dung biomanure the yield potential of *Volvariella* mushroom increased to a great extent. However, humidity and temperature of the environment largely affect the productivity of this mushroom. In the present experiments average temperature ranging from 30-32 °C and average humidity ranging from 66-68 per cent were found favourable for cultivation of *Volvariella volvacea* mushroom.

Analyses of protein, carbohydrate and lipid of mushroom are presented in Table 5 wherefrom it would be evident that protein content increased when grown with biomanure or $(NH_4)_2HPO_4$ while a reverse trend is noticed in respect of carbohydrate content. This indicates that the metabolic pathways are reoriented towards protein synthesis when rice straw was supplemented with biomanure. The maximum gain in protein was recorded when biomanure was supplemented in 1:1 ratio. There

Table 6 – Effect on mineral contents in *Volvariella volvacea* due to supplementation by biomanure*

Treatments	Ash (Per cent)	Elements present						
		Per cent			ppm			
	P	Na	K	Ca	Cu	Fe	Zn	Mn
Straw 100 per cent	11	1.18	0.58	5.68	49.8	30.7	278	102	49.1
Straw + 0.1 per cent $(NH_4)_2HPO_4$	8.6	1.2	0.23	4.87	60.4	71.8	230	123	45.9
Straw + Biomanure (1 : 1)	11.5	1.25	0.45	4.8	76.4	45.3	301	99	47
Straw + Biomanure (2 : 1)	11.4	1.24	0.32	5.12	65.9	39.1	251	94	52.9
Straw + Biomanure (1 : 2)	10.6	1.27	0.4	5.51	152.6	73.3	269	100	45.9

* See text

was practically no change in lipid content due to the above treatments.

Increase in mineral nutrients due to supplementation by these biomanures were not uniform. From results presented in Table 6 it can be noted that increase of P, K, Ca and Cu was highest using straw and biomanure in 1:2 ratio while Mn showed a reverse trend in this combination. However, considering all the elements studied, increase of mineral nutrients was found when supplementation was done in 1:1 ratio. Thus considering the yield factor as well as protein content, straw : cattledung biomanure in 1:1 ratio is the best combination for cultivation of *Volvariella volvacea* mushroom.

Conclusions

Biogas residual slurry manures are rich in mineral nutrients and are very effective for increasing yield of *Volvariella* mushroom . Biomanures obtained from cattle dung increased biological efficiency of this mushroom significantly when supplemented with rice straw in 1:1 ratio. The mushroom produced from this substrate was richer in protein and mineral nutrients viz., P, K, Ca , Fe, Cu, Zn, and Mn with lower carbohydrate content. Thus supplementation of rice straw with cattle dung biomanure in 1:1 ratio is reccommended for cultivation of nutritious as well as commercial profitability of *Volvariella* mushroom.

An application has been submitted for patent No. 72/ Cal/98 dated 15.01.1998 entitled " A method of producing for mushroom cultivation by utilising biogas waste slurry and straw for improved mushroom cultivation" by ICAR; Inventor Dr. S. Banik, NIRJAFT, Calcutta.

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